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THE NIAGARA ESCARPMENT

By

D. F. Hewitt

INDUSTRIAL MINERAL REPORT No. 35

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AND NORTHERN AFFAIRS

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D. F. Hewitt

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THE NIAGARA ESCARPMENT

By

D.F. Hewitt[1]

The Niagara Escarpment is a prominent geological feature which extends westward from Queenston on the Niagara River to Dundas and thence north through Milton, Limehouse, Caledon, Mono Centre and Dunedin to Craigleith on Georgian Bay, thence westerly in a serrated fashion to Owen Sound. From Owen Sound, the Niagara Escarpment forms the eastern shore of the Bruce Peninsula, as far as Tobermory, where it disappears beneath the waters of Lake Huron, and reappears along the north shores of Manitoulin, Cockburn, Drummond and St. Joseph Island. From this point the Niagara Escarpment passes into the northern peninsula of the State of Michigan. East of Queenston on the Niagara River, the Niagara Escarpment parallels the shore of Lake Ontario in New York State.

Throughout Southern Ontario the Niagara Escarpment has a length of over 380 miles from Queenston to St. Joseph Island. The actual length of the face is much greater due to its promontories and reentrant valleys.

Although as a geological feature the Niagara Escarpment is continuous from Queenston to Tobermory, it is not always present as a prominent topographic feature due to its mantling or burial by later deposits of glacial drift. The scarp is buried for considerable stretches in portions of Caledon, Albion, Mono and Mulmur Townships.

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[1]Chief, Industrial Minerals Section, Geological Branch, Ontario Department of Mines and Northern Affairs, Toronto.

Definition of an Escarpment

Fairbridge (1968, p. 322), in the Encyclopedia of Geomorphology, states that "an escarpment or scarp is defined as a cliff or steep rock face of great length. Two general types are recognized - structural and erosional escarpments." The structural escarpments are scarps formed due to faulting, either fault scarps or fault-line scarps. The erosional escarpments are formed by differential erosion, generally where a hard scarp-forming rock is underlain by softer, more easily eroded rocks. This is the case in the Niagara Escarpment, where the hard and resistant Lockport or Amabel Dolomite dips gently to the southwest and is underlain by softer shales, sandstones and dolomites of the Clinton and Cataract Groups and by the soft Upper Ordovician shales of the Queenston and Georgian Bay Formations. The initial scarp-former of the Niagara Escarpment is the Lockport or Amabel Dolomite of Silurian age.

In referring to the "Dictionary of Mining, Mineral and Related Terms" of the U.S. Department of the Interior, 1968, we find the following definitions for escarpment: "a. A cliff or relatively steep slope separating level or gently sloping tracts. Fay. b. In gently inclined strata, the abruptly truncated and clifflike outcrops of the resistant beds are called escarpments. A.G.I.

c. The steep face presented by the abrupt termination of strata. A.G.I."

The two latter definitions are from the American Geological Institute's "Glossary of Geology and Related Sciences, 1960".

The consensus of these definitions is that an escarpment is a steep rock face of relatively great length formed by the abrupt termination of strata.

Thornbury (1954, p. 258) has described the occurrence of scarps across alluvial deposits. He states "Alluvial Scarps are low scarps usually in alluvium, which are found at the bases of fault block ridges." These alluvial scarps are fault scarps of recent origin and would be unlikely to maintain their form for any great length of time.

Brow or Edge

The brow or edge of the escarpment is the point where the gradient changes from gentle to steep. Where the escarpment is due to the presence of a resistant scarp former, the brow or edge will be marked by a cliff or steep bluff of rock.

Face

The face of the escarpment includes the area of steep gradient between the edge and the base of the escarpment. In the case of a multiple or terraced escarpment, more than one

scarp former may be present on the escarpment face and these may be separated by terraces.

Base

The base of the escarpment is the point on the escarpment profile where the gradient changes from steep to gentle. Where the base of the escarpment is mantled by drift, it may be difficult to establish the exact position of the base of the escarpment.

Size of Some Ontario Escarpments

At its type section at Niagara Falls, the Niagara Escarpment has a height of approximately 300 feet. The maximum height of the Niagara Escarpment on land is 875 feet at The Caves, a short distance south of Craigleith, where the escarpment section extends from the Amabel Dolomite above to the base of the Georgian Bay Formation below. In some reentrant valleys, as at Campbellville, the height of the face of the Amabel scarp-former may not exceed 15 to 20 feet.

The Black River Escarpment, which marks the contact of the Paleozoic limestone and the Precambrian rocks across Southern Ontario from Midland to Kingston, ranges from 5 feet to about 75 feet in height and frequently does not exceed 15 feet in height.

The Onondaga Escarpment which is formed in resistant cherty limestone of the Bois Blanc Formation extends from Fort Erie to Hagersville where it becomes buried. Between Fort Erie and Hagersville, this escarpment ranges from a few feet to about 30 feet in height.

Types of Escarpments

Over its length the Niagara Escarpment is usually present as a prominent topographic feature, and this is the popular conception of an escarpment. However the Niagara Escarpment is present in many forms throughout its length in Southern Ontario, the principal of which are the rock scarp, the mantled scarp, the buried scarp, the terraced scarp, the multiple scarp, the incised scarp, the outlier and the stripped scarp.

The Rock Scarp:

For the Niagara Escarpment to be present as an unmantled rock scarp is rather unusual. A rock scarp is present at the type section at Niagara Falls and in the Niagara Gorge where there is little overburden. A rock scarp is also present from the Lockport Dolomite down to the Queenston Shale at DeCew Falls where the Hydro penstocks descend the rock face of the Escarpment. In most other places, as along the east shore of the Bruce Peninsula, only the dolomite cliffs may be present as

Photo 1. The Niagara Escarpment is present as an unmantled rock scarp in the Niagara Gorge as shown in this photo at the Whirlpool Rapids in the Niagara River. Photo courtesy of the Ontario Department of Tourism and Information.

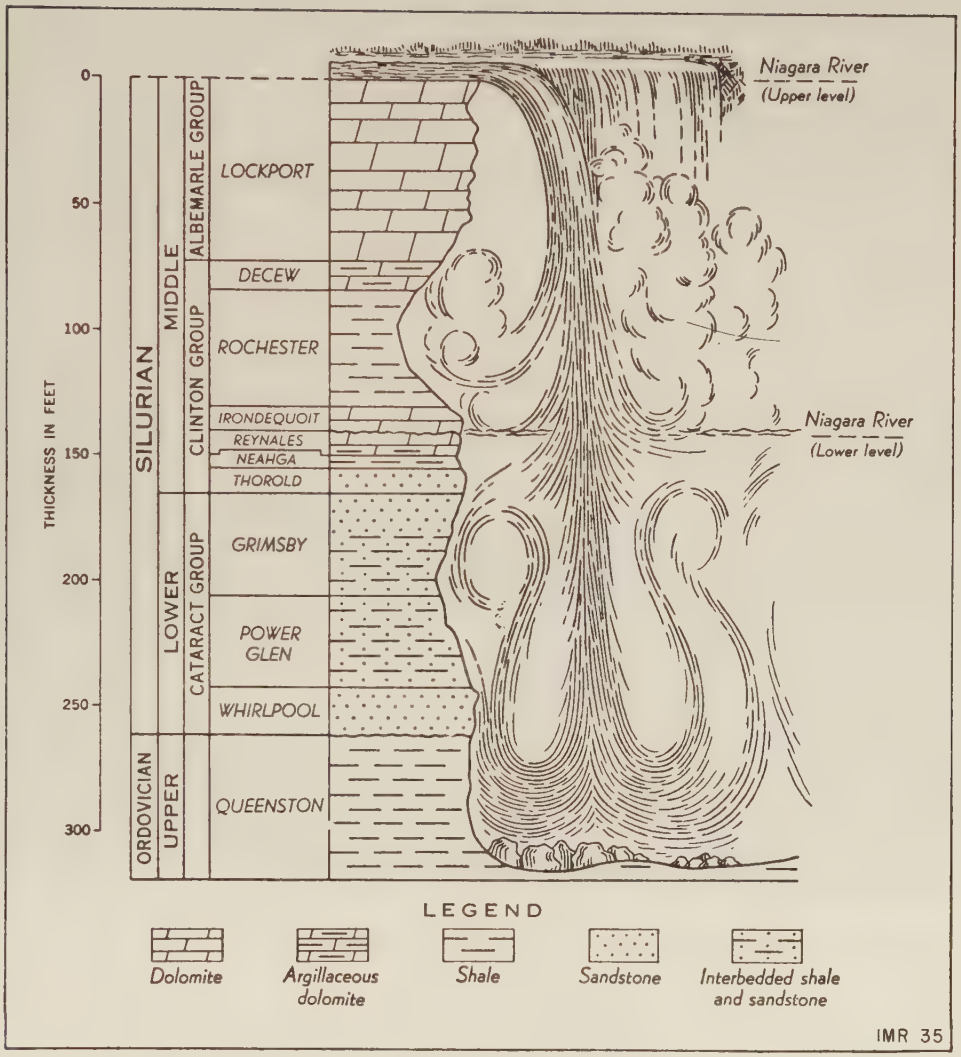

Figure 1 - Stratigraphic Section at Niagara Falls
(courtesy of Geol. Surv. Canada)

a rock scarp. At Osler Bluffs where the Niagara Escarpment attains a near maximum in relief, there is some mantling of the rock face of the scarp. The stratigraphic section at Niagara Falls is shown in Figure 1.

The Mantled Scarp:

The most common type of expression of the Niagara Escarpment is the "mantled scarp". In its normal expression as seen at the Milton outlier, the upper part of the scarp, consisting of a rock face of Amabel Dolomite up to 100 feet in height, is exposed. The lower flanks of the Escarpment are mantled by glacial drift, and frequently the only rock exposed may be the Amabel Dolomite Formation.

The Buried Scarp:

The carving of the erosional escarpment which we know as the Niagara Escarpment took place largely in pre-Pleistocene times. During Pleistocene times the Georgian Bay ice lobe moving southward from Georgian Bay, and the Lake Ontario ice lobe, moving north and west out of the Lake Ontario basin, met along a line extending west from Trenton to the Niagara Escarpment in the vicinity of Caledon. Extensive lateral and end moraines were built up between and flanking the two ice lobes and in places the Niagara Escarpment was buried under

Photo 2. The most common expression of the Niagara Escarpment is the mantled scarp as shown in this photo near Jones Bluff on the Cape Croker Indian Reserve, Bruce Peninsula. Here there is an Amabel-dominant rock scarp present on the right, with the lower flanks of the Escarpment being mantled by glacial drift. Photo courtesy of the Ontario Department of Tourism and Information.

Photo 3. In the Beaver Valley, as shown here near Kimberley, The Niagara Escarpment takes the form either of a buried scarp or a mantled scarp with some exposures of Amabel rimrock. In this photo the scarp is buried in places, with Amabel rimrock exposed sporadically along the crest of the valley wall. The position of the edge of the Escarpment can be ascertained by the elevations of the exposures of the Amabel scarp which are present. Photo courtesy of the Ontario Department of Tourism and Information.

these glacial deposits.

In Caledon Township the Niagara Escarpment is well exposed at Caledon Mountain and the Forks of the Credit, but northeastward from the Forks of the Credit to Sleswick the face of the Niagara Escarpment is almost completely buried by the Paris Moraine which lies along the position of the buried face of the Escarpment. To the north of the Paris Moraine is the Caledon meltwater channel, described by White (1969, p. 103), which extends from Sleswick, past Star, to Caledon. In places, as at Star, the north wall of this meltwater channel exposes rocks of the Amabel Formation and Clinton Group which form the brow of the Niagara Escarpment at this point.

The position of the buried scarp in Caledon Township can be established by outcroppings of Amabel Dolomite on the brow of the Escarpment at Sleswick and Star, and by the bedrock contours which indicate the position of the buried scarp face below the brow or crest.

The Caledon Hills, extending from the Forks of the Credit northeastward to the eastern Caledon Township boundary, are formed of a slope of Galt Moraine built up against, and burying, the face of the Niagara Escarpment. The correspondence between the bedrock relief due to the presence of the Niagara Escarpment and the topographic relief expressed by the presence of the Caledon moraine hills is very close. The presence of the

buried Niagara Escarpment is fundamental to the development of the Caledon Hills which are composed of moraine, the position of the moraine slope of the Caledon Hills being south of the actual buried rock scarp. The Caledon Hills might be said to be a consequent slope reflecting the underlying buried rock scarp.

From Sleswick to Mono Mills the edge of the Niagara Escarpment arcs to the northeast into Albion Township. Outcrops marking the position of the edge of the Escarpment are present at Sleswick and The Dingle but the scarp face in Albion Township is almost wholly buried by the Gibraltar Moraine (White 1969, p. 103). The northeastern margin of the Gibraltar Moraine in Albion Township is a consequent slope in moraine. The Mono Mills meltwater channel flowed north from Sleswick through Mono Mills to the Hockley Valley along the northeast edge of the Niagara Escarpment. On both sides of the Airport Road north of Mono Mills an extensive flat-topped gravel terrace was laid down in the Mono Mills meltwater channel.

The edge of the Niagara Escarpment forms a hill west of

the Airport Road in Mono Township at an elevation of approximately 1475 feet a.s.l. The gravel terrace with an elevation of approximately 1425 feet a.s.l. completely buries the face of the Niagara Escarpment in this area, and the terrace has a width of approximately one mile. The consequent slope in this area which constitutes the topographic expression of the buried Niagara Escarpment is the eastern edge of the gravel terrace in concessions VII and VIII of Mono Township. This slope might be said to form a consequent terrace resting over the buried scarp face.

Multiple Scarps:

The principal scarp-former of the Niagara Escarpment is the Lockport or Amabel Dolomite which forms a resistant caprock throughout most of the length of the Escarpment. This is the dominant scarp-former, and in many places it is the only scarp-former. However in several localities the Niagara Escarpment consists of multiple scarps with either two, or three scarp-formers. At Queenston Quarries a double scarp is present with the Lockport-dominant scarp at the top and a

Photo 4. Skinner Bluff is a cliff of Amabel Dolomite east of Wiarton in Keppel Township. It is the uppermost of multiple scarps which form the Niagara Escarpment in Keppel Township. Photo courtesy of the Niagara Escarpment Study Group.

subsidiary scarp of Irondequoit and Reynales Limestone forming a shelf part way down the escarpment face. Farther to the west, between Rockway and Beamsville, a double or triple scarp may be present with the scarp-formers being the Lockport, Irondequoit and Whirlpool Formations. Where a multiple scarp is present, the face of the Niagara Escarpment is terraced, with a steep gradient being interposed with a relatively flat terrace on the top of the subsidiary scarp former. These terraces may range from a few tens of feet to over a mile in width.

The predominant subsidiary scarp formers in the Niagara Escarpment are the Irondequoit Limestone, the Whirlpool Sandstone, the Manitoulin Dolomite and the upper member of the Georgian Bay Formation. Terraces capped by Manitoulin Dolomite are particularly prevalent in the area between Collingwood and Owen Sound. At Cape Rich, for example, three scarps are present, the Amabel scarp, the Manitoulin scarp and the Georgian Bay Formation scarp. These are all members of the main Niagara Escarpment. A fourth scarp which represents the shoreline of glacial Lake Nipissing forms a shorecliff not far from the present shore of Georgian Bay.

The Incised Scarp:

The normal section of the Niagara Escarpment as exposed

at Niagara Falls consists of a caprock of resistant Lockport Dolomite underlain by nearly 200 feet of shales, limestone and sandstones of the Clinton and Cataract Groups, with the base of the Escarpment being in the upper 50 to 75 feet of the Queenston Shale. Normally the Queenston Shale is the lowermost formation exposed in the Niagara Escarpment and only the upper 10 to 75 feet make up part of the Escarpment.

The axis of the Algonquin arch trends northeast through Southwestern Ontario and passes across the Niagara Escarpment at or near Duntroon where the Escarpment attains a height of over 1700 feet a.s.l. It is probable that the area of the Niagara Escarpment along and adjacent to the Algonquin Arch was a positive rising element during late Tertiary Times with respect to the rest of the Niagara Escarpment. Due to the rising of this land and the maintenance of the general base level of erosion, the Niagara Escarpment was incised or cut down much below the normal stratigraphic position of the base and in the area between Creemore and Craigleith, all of the Queenston Formation and all or a large part of the Georgian Bay Formation form part of the Niagara Escarpment.

The Niagara Escarpment at The Caves and at Osler Bluff is an example of the incised scarp.

The Stripped or Uncapped Scarp:

During Pleistocene times the Georgian Bay ice lobe moved strongly to the south and southeast out of Georgian Bay. The abrasion and scouring action of the ice is evidenced by the great prevalence of boulders and blocks of Amabel Dolomite in the glacial drift. It is apparent that considerable thicknesses of Amabel Dolomite must have been removed by the action of the Georgian Bay lobe. In places the caprock of Amabel Dolomite appears to have been stripped back from its original position at the edge of the Escarpment leaving some lengths of stripped or uncapped scarp in places.

One example of a stripped section of scarp may be seen south of Creemore, where the Amabel Dolomite is absent on top of the scarp for a distance of over three miles to the southern boundary of Nottawasaga Township, east of Lavender.

The northernmost section of the Blue Mountains just southeast of Camperdown appears to have been stripped of Amabel caprock. Stripping was also probably very active on the headland between Owen Sound and Nottawasaga Bay where the three Manitoulin Dolomite outliers of Coffin Hill, Silcote and St. Vincent have no overlying rocks.

Outliers:

Outliers are defined as "portions of any stratified group which lie detached, or out from the main body, the intervening or connecting portion having been removed by denudation", A.G.I. The outliers of the Niagara Escarpment form islands lying east or north of the main front of the escarpment, and separated from the main escarpment by a valley. These outliers form part of the Niagara Escarpment and should be treated as integral parts of the Escarpment for the purposes of control of Niagara Escarpment lands.

Among the more prominent outliers are the following: the Milton, Georgetown, Star, Caledon, Mono Centre, Ruskview, Creemore, Camperdown, St. Vincent, Silcote, Coffin Hill, Pyette Hill and Kings Point outliers.

Some of the outliers, such as the Milton and Georgetown outliers, are separated outliers in which the valley or channel separating the "island" of the outlier from the "mainland" of the Escarpment is cut down below the basal unit of the escarpment. In the cases cited this formation is the Queenston Shale.

Some of the outliers, such as Camperdown, St. Vincent, Silcote and Coffin Hill, are attached outliers in which the valley or channel separating the "island" of the outlier from the "mainland" of the Escarpment is not cut down below the basal unit of the Escarpment in that vicinity.

Photo 5. Along the east and north shores of the Bruce Peninsula the lower flanks of the Niagara Escarpment are drowned by the waters of the Georgian Bay. Outliers lying offshore from the main scarp form islands in the Bay. One such island outlier is Flowerpot Island shown above with its steep rock scarp face of dolomite. Photo courtesy of the Ontario Department of Tourism and Information.

As mentioned in the previous section on stripped or uncapped scarps, the outliers may also be stripped or uncapped as is the case in the Creemore, St. Vincent, Silcote and Coffin Hill outliers.

The Creemore outlier is unusual in that it is an example of an incised stripped outlier. The flanks of the outlier have been incised through the Queenston Formation and well into the Georgian Bay Formation and the outlier was later stripped of overlying Amabel, Clinton and Cataract rocks probably by glacial denudation. The outlier is capped by Queenston Shale, a most remarkable feature in view of the relative softness of the shale. This would indicate that the last major denudation may have occurred as late as Wisconsinan times.

Geology of the Niagara Escarpment

The type section of the Niagara Escarpment is at Niagara Falls, and the Niagara Escarpment is there defined as a steep rock face comprising the rocks of Lockport Formation, the Clinton and Cataract Groups, and the upper part of the Queenston Formation. Over its length from Niagara Falls to Tobermory, the stratigraphy of the Niagara Escarpment deviates somewhat from the type section at Niagara Falls, shown in Figure 1. North of Waterdown the term Lockport is replaced by Amabel, these formations being equivalent. Along the north shore of the Bruce Peninsula from Wingfield Point to Tobermory, the steep rock face of the Niagara Escarpment along this Georgian Bay coastline is capped by Guelph Dolomite, and the face includes a complete section of Amabel Dolomite. This is the highest stratigraphic extent of the Niagara Escarpment and is only typical of this part of the Bruce Peninsula.

As mentioned previously in the area of the maximum influence of the Algonquin Arch, between Camperdown and Creemore, the Niagara Escarpment has been incised due to uplift as far down as the base of the Georgian Bay Formation, and includes the entire Queenston Formation which is thinning in this area.

Table 1. CLASSIFICATION OF STRATIGRAPHY OF THE NIAGARA ESCARPMENT

(after Bolton 1957)

		Niagara Peninsula (Niagara Falls-Hamilton)				Hamilton-Tobermory, and Manitoulin Island		
				Formation	Member		Formation	Member
Silurian	Niagaran Series (Middle Silurian)	Albemarle Group		Guelph		Albemarle Group	Guelph	
				Lockport	Eramosa Goat Island Gasport		Amabel	Eramosa Wiarton Colpoy Bay Lions Head
							?	?
		Clinton Group	Upper	DeCew Rochester Irondequoit		Clinton Group		
			Mid.					
			Lower	Reynales Neahga Thorold			Fossil Hill St. Edmund Wingfield Dyer Bay	
	Alexandrian Series (Lower Silurian)	Cataract Group		Grimsby Power Glen Whirlpool		Cataract Group	Cabot Head Manitoulin Whirlpool	
Ordovician				Queenston			Queenston	
		Nottawasaga Group		Georgian Bay		Nottawasaga Group	Georgian Bay	

Photo 6. The type section of the Niagara Escarpment is at Niagara Falls, where a steep rock scarp composed of rocks of the Lockport Formation, the Clinton and Cataract Groups, and the upper part of the Queenston Formation forms the Escarpment. Photo courtesy of the Ontario Department of Tourism and Information.

The classification of the stratigraphy of the Niagara Escarpment is given in Table I, after Bolton (1957, p.5). T.E. Bolton's memoir on "Silurian Stratigraphy and Palaeontology of the Niagara Escarpment in Ontario" is the definitive work on the Silurian geology of the Escarpment (Bolton 1957).

The type section of the geological formations exposed in the Niagara Escarpment in the Niagara Gorge at the Sir Adam Beck-Niagara Generating Station No. 2, Access Road, Niagara Falls, Ontario, after Bolton (1964, p.66), is given in Table 2. Other geological sections are given by Bolton (1957).

Rock Formations

Guelph Dolomite

The Guelph Dolomite overlies the Lockport and Amabel Formations and generally lies west or south of the Niagara Escarpment throughout the entire area from Queenston to the Bruce Peninsula. However there are three areas where the Guelph Dolomite approaches and becomes part of the brow of the Niagara Escarpment. The first locality is at the old Dundas quarry of Canada Crushed Stone at Dundas; the second locality is for a stretch of about one and a half miles in the cliff between White Bluff and Smoky Head on the Bruce Peninsula; the third locality is for a stretch of 17 miles along the north shore of the Bruce Peninsula from Cabot Head to Tobermory.

Table 2

Section at Niagara Falls
Sir Adam Beck - Niagara Generating Station
No. 2, Access Road,
Niagara Falls, Ontario

Formation or Member	Description	Thickness in feet
Goat Island	Dolomite; light grey, dense to very finely crystalline; buff weathered, massive with thinner bedded, dark blue-grey to buff dolomite near top of section; rare thin crinoidal lenses; conchoidal fracturing; vugs throughout though heavier concentration in lower part, filled with gypsum, calcite, and sphalerite	17.5
Gasport	Limestone, dolomitic; grey, crystalline, crinoidal; massive to poorly bedded, buff weathered; very porous; upper contact undulating, sharp due to both colour and lithic change, crinoid columnals in concentrations locally below contact; lower contact sharp, undulating as much as 4 inches, thin elongate pebbles up to 1-3/4 inches present just above contact and throughout basal 14 inches; poorly preserved corals and stromatoporoids concentrated in lower beds of grey-blue limestone.	44.5
DeCew	Dolomite; grey, dense, to very finely crystalline, thin-to thick-bedded; conchoidal fracturing; mud galls.	8
	Mudstone calcareous; dark grey; intercalations of harder material, very finely crystalline in part; lower contact undulating as much as 6 inches.	3.5
Rochester	Shale; dark grey, calcareous; lower half with many grey limestone interbeds, poorly exposed; upper beds more calcareous with finely crystalline dolomite; lower contact sharp; fossils never abundant, mainly in lower half.	55
Irondequoit	Limestone, dolomitic; grey to reddish brown, massive, dense to crystalline; lower contact sharp.	9.5

Formation or Member	Description	Thickness in feet
Reynales	Dolomite; light grey to blue; fine to medium crystalline, thin-bedded, buff weathered; thin grey shale interbeds in upper 2 feet; shale with phosphatic nodules 8 inches above lower contact.	11
	Shale; grey.	0.25
	Limestone; brown, fine to medium crystalline; blue chert nodules.	0.25
	Limestone; grey to blue, fine to medium crystalline; green argillaceous galls and green shale partings; fossiliferous - small corals, brachiopods, etc.	2.25
Neahga	Shale; green in upper 2-1/2 inches underlain by 2 inches very fine, crystalline blue limestone; remainder shale; upper contact sharp.	7
Thorold	Sandstone; white to light green; 2-1/2 inches of red shale with red stained sandstone located 8-1/2 inches above base; lower contact sharp on red shale.	6.5
Grimsby	Sandstone; red, green mottled, irregularly bedded; red shale interbeds passing downward into red, green mottled shale with sandstone interbeds.	50
Power Glen	Shale; dark grey to greenish grey; light grey to white, calcareous sandstone interbeds throughout, with more pronounced units or lenses 2, 16, and 27 feet above base.	36
Whirlpool	Sandstone; white to light grey; massive, thicker bedded in upper part; crossbedded.	18.5
Queenston	Shale; brick red, green mottled to streaked.	6+

from Bolton (1964, p.66)

The Guelph Dolomite consists of light creamy buff, light buff weathering, aphanitic to fine or medium crystalline, porous dolomite, generally thick-bedded. The lower contact with the Eramosa is marked by a change to medium to dark brown, bituminous dolomite with dark grey shaly streaks.

The Guelph Dolomite is also characterized by reefy facies. These consist of medium to coarsely crystalline, irregularly bedded or massive areas of highly fossiliferous, porous dolomite standing out as mounds or bioherms within the surrounding bedded dolomite.

The contact of the Guelph Dolomite and the underlying Eramosa Dolomite is seen at Canada Crushed and Cut Stone quarry at Dundas where 7 feet of Guelph Dolomite overlie 43 feet of Eramosa Dolomite. This contact is also exposed at the Guelph quarry of the Canadian Gypsum Company. The Guelph Dolomite has a thickness of 100 to 200 feet in the outcrop area and forms a belt up to 20 miles wide, west of the Amabel Dolomite outcrop.

The Guelph-Lockport and Guelph-Amabel Dolomites form a wide belt, as shown on Map 2117, extending from Queenston to the Bruce Peninsula. This outcrop belt has an average width of 10 miles in the Niagara Peninsula and 24 miles from Dundas to the Bruce Peninsula. The thickness of the Guelph-Lockport in the Niagara Peninsula averages about 200 feet; the Guelph-Amabel in the area to the north thickens to 400 feet near Owen Sound.

Lockport Dolomite

The Lockport Dolomite forms the crest of the Niagara Escarpment from Queenston to Waterdown, and the Amabel Dolomite forms the crest of the escarpment from Waterdown north to Cabot Head on the Bruce Peninsula. From Queenston to Waterdown the Lockport Dolomite dips gently to the south and has an outcrop width of up to six miles. At Dundas the thickness of the Lockport Dolomite is about 135 feet (Caley 1940, p.57).

The Lockport Formation is divided into three members; in ascending order these are the Gasport Member, the Goat Island Member, and the Eramosa Member. The Gasport, the lowest member of the Lockport Formation is a medium crystalline, crinoidal dolomitic limestone or dolomite, generally massive to thick-bedded, bluish grey to light buff in colour. It varies in thickness from 4.4 feet at Stoney Creek to 33 feet at Queenston Quarries. This member is quarried for building stone by Queenston Quarries. The Gasport Dolomite rests unconformably on the underlying Decew Dolomite, or, where this formation has been removed by erosion, on the Rochester Shale. The unconformable contact of the Gasport and Decew Dolomites is well shown at Walker Brothers quarry at Thorold. The Gasport greyish crinoidal dolomite grades upward into brownish to light buff, fine crystalline to aphanitic dolomite of the Goat Island Member.

The Goat Island Member is an aphanitic to fine crystalline, light buff to light brownish grey, massive to thick bedded dolomite. In places bluish-grey and white chert are abundant. The chert-bearing facies has been distinguished as the "Ancaster chert beds". The chert beds generally occur at the base of the Goat Island Member and are most common in the Ancaster-Stoney Creek area. The thickest section of Goat Island Dolomite measured by the writer was 32 feet at St. Catharines Crushed Stone quarry. The upper limit of the Goat Island Dolomite is arbitrarily drawn at the first appearance of dark brown to black bituminous material characteristic of the dark brown sugary Eramosa Member.

The Eramosa Member is a dark brown to medium brownish grey, aphanitic to sugary, medium to thin-bedded, dark grey streaked dolomite with bituminous or shaly partings. The typical Eramosa dolomite is exposed in the 50-foot quarry face at the Dundas quarry of Canada Crushed and Cut Stone Limited. It is also exposed at Vinemount Quarries and the A. Cope and Son quarry, Stoney Creek. In these latter quarries the Vinemount shale beds of the Eramosa Member are exposed near the base of the Eramosa and have a maximum thickness of 17 feet. This shaly unit has poor soundness and is unsatisfactory for concrete aggregate. The Eramosa Dolomite apparently attains its maximum thickness at Dundas where 58 feet are exposed in the old quarry

of Canada Crushed Stone. It is overlain by the light buff dolomite of the Guelph Formation.

Amabel Dolomite

Throughout the Niagara Peninsula and as far north as Clappisons Cut, the Lockport Formation is divided into three members: Gasport, Goat Island and Eramosa. However in the Clappisons Cut-Waterdown area there is a noteworthy facies change and this Lockport stratigraphic unit is replaced by a reefy, medium crystalline, light buff dolomite, which extends from Waterdown through Georgetown to the Bruce Peninsula. This facies, which is the lateral equivalent of the Lockport, is named the Amabel Formation by Bolton (1957, p.51). The Lockport Dolomite therefore changes its name and lithology in the Waterdown area to the Amabel Dolomite.

The Amabel Dolomite forms the crest or brow of the Niagara Escarpment from Waterdown north to Cabot Head on the Bruce Peninsula. West of Wingfield Point the brow is Guelph Dolomite. The Amabel Dolomite dips gently to the southwest and outcrops over a width of up to 12 miles west of the Escarpment.

As indicated in the "Lockport-Amabel Sections", Figure 2, the quarry sections from Waterdown to Georgetown are all in the reefy Amabel Dolomite. In this area the formation is not divided into members, but consists of a light grey to buff,

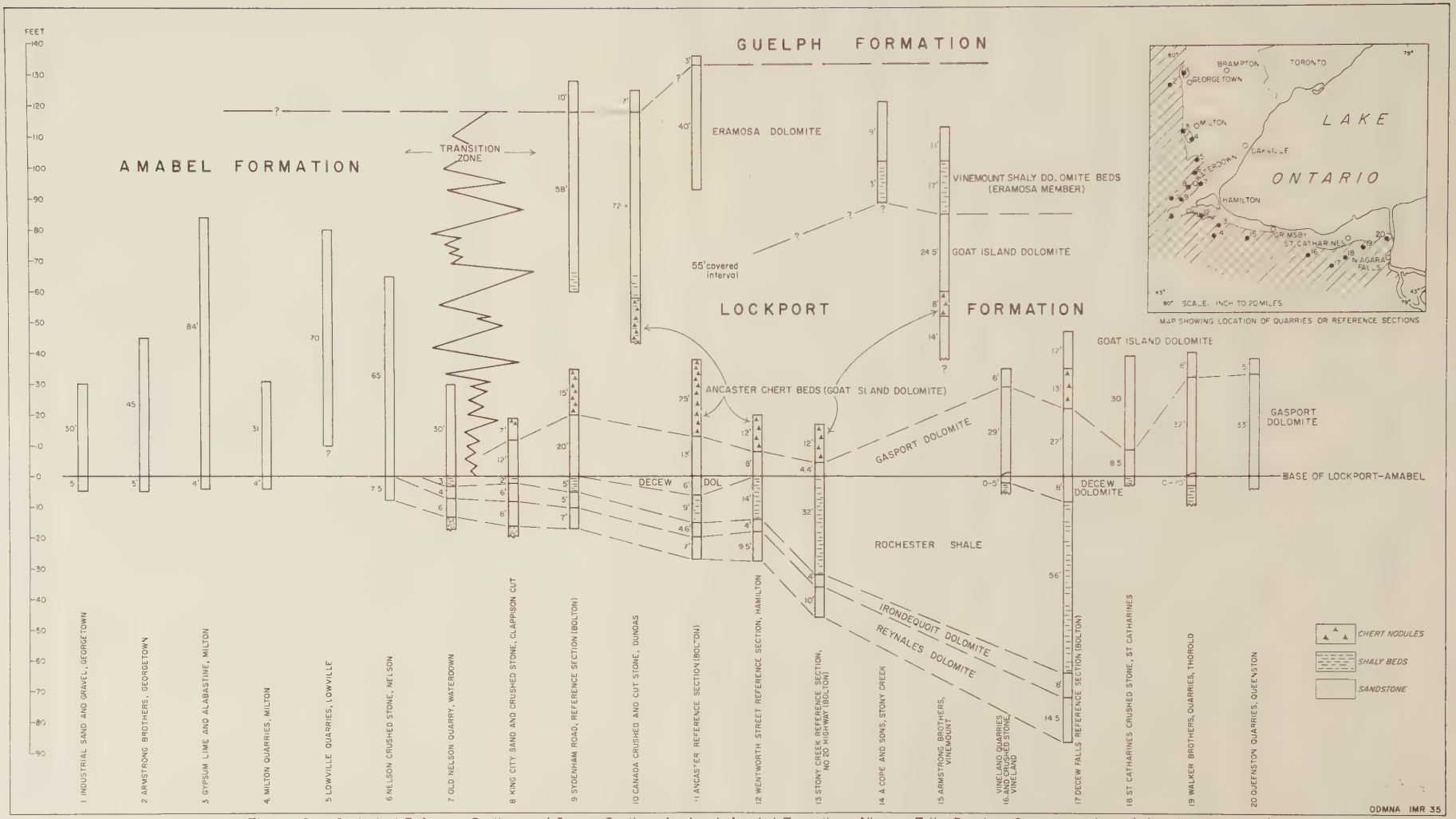

Figure 2 – Geological Reference Sections and Quarry Sections, Lockport–Amabel Formations, Niagara Falls–Dundas–Georgetown Area (after Hewitt 1960)

buff-weathering, medium to coarse crystalline, massive to irregularly bedded and reefy, fossiliferous dolomite. The maximum thickness exposed is 84 feet at the old Milton quarry of Domtar Chemicals Limited.

In the Bruce Peninsula, Bolton (1957, p.51 - 57) divides the Amabel Formation into four members: Lions Head Dolomite, Colpoy Bay Dolomite, Wiarton Dolomite and Eramosa Dolomite.

As indicated in the Lockport-Amabel Sections, Figure 2, the Amabel Dolomite in the area from Nelson Crushed Stone quarry to Georgetown, rests on the Reynales Dolomite of the Clinton Group.

The upper member of the Amabel Dolomite is the brown, sugary, medium to thin-bedded, bituminous Eramosa Dolomite. The contact of the Eramosa Dolomite and the overlying Guelph Dolomite is exposed in the Guelph quarry of Canadian Gypsum Company.

Clinton Group

As indicated on Table 1, Classification of the Stratigraphy of the Niagara Escarpment, at the type section at Niagara Falls, the Clinton Group consists, in descending order, of the DeCew Formation, the Rochester Formation, the Irondequoit Formation, the Reynales Formation, the Neahga Formation and the Thorold Formation. In the Bruce Peninsula area, the Clinton Group consists in descending order of the Fossil Hill Formation, the

St. Edmund Formation the Wingfield Formation, and the Dyer Bay Formation.

DeCew Formation

In the Niagara Escarpment type section at Niagara Falls, the DeCew Formation consists of 8 feet of grey dolomite, dense to fine crystalline, thin to thick-bedded, with mud galls, underlain by 3.5 feet of calcareous, dark grey mudstone. The upper surface of the DeCew is an erosion surface and the formation has a remarkably varied thickness. At Walker Brothers quarry at Thorold the DeCew varies from zero to 20 feet in thickness. The DeCew formation has its last appearance in the Niagara Escarpment sections at Ancaster where it has a thickness of six feet.

Rochester Formation

In the Niagara Escarpment type section at Niagara Falls, the Rochester Formation consists of 55 feet of dark grey, calcareous shale with many dolomite interbeds in the lower part of the formation. The upper contact with the DeCew Formation is gradational, and the lower contact is sharp. Fifty-six feet of Rochester Formation are described by Bolton (1957) at DeCew Falls. West of this locality the Rochester thins rapidly and wedges out to the west and north. Its last appearance in Niagara

Escarpment sections is at the Old Nelson quarry at Waterdown where it is 3 feet thick (Hewitt 1960, p.113).

Irondequoit Formation

In the Niagara Escarpment type section, the Irondequoit Formation consists of 9.5 feet of grey to reddish brown, massive, dense to crystalline dolomitic limestone. Its last easily recognizable appearance in the Niagara Escarpment sections is at the Old Nelson quarry at Waterdown where it is 4 feet thick, and is separated from the overlying Amabel Dolomite by three feet of Rochester Shale. Farther north the Irondequoit equivalent forms a grey crystalline basal unit of the Amabel Formation and is indistinguishable from the Amabel Formation.

Reynales Formation

In the Niagara Escarpment type section at Niagara Falls, the Reynales Formation consists of 13.75 feet of light grey to blue, thin-bedded, fine crystalline dolomite with shaly partings. Due to the wedging out of the overlying Irondequoit, Rochester and DeCew Formations near Waterdown, the Reynales Dolomite occurs immediately below the Amabel Dolomite in the Nelson Crushed Stone quarry, Lowville Quarries, Milton Quarries, Halton quarry, Dufferin quarry, Georgetown quarry of Armstrong Brothers Company,

the Industrial Sand and Gravel quarry at Georgetown and the Acton quarry of Indusmin Limited. The Reynales Dolomite is not recognized in Niagara Escarpment sections north of Acton. From Waterdown north the Reynales is a dense aphanitic dolomite easily recognizable from the overlying crystalline dolomite of the Amabel Formation.

Neahga Formation

In the Niagara Escarpment type section at Niagara Falls, the Neahga Formation consists of 7 feet of green shale with a single thin limestone interbed. The formation pinches out to the west and its last appearance is at Grimsby Beach where 3 inches are present (Bolton 1957, p.86).

Thorold Formation

In the Niagara Escarpment type section at Niagara Falls, the Thorold Formation consists of 6.5 feet of white to light green sandstone with minor interbeds of red shale. Green shale interbeds are prevalent to the west, and grey and green shales are abundant from Stoney Creek to the north. The last appearance of the Thorold Formation in the Niagara Escarpment sections is at Clappisons Corners (Bolton 1957, p.93). North of Clappisons Corners the Thorold equivalent is present in the upper part of

the Cabot Head Formation.

Fossil Hill Formation

The uppermost formation of the Clinton Group from Caledon Township northward is the Fossil Hill Formation which underlies the Amabel Formation. The Fossil Hill Formation is transitional to the Reynales Formation between Caledon and Acton (Bolton 1957, p.40). The southernmost section of the Fossil Hill Formation is at Star in Caledon Township where there are seven feet of brown, fine crystalline, massive to thin bedded, fossiliferous dolomite. This is overlain by the Amabel Dolomite and underlain by the Cabot Head Shale.

The Fossil Hill Formation is the only member of the Clinton Group present at Cannings Falls and Hornings Mills, but is underlain by the Dyer Bay Formation in St. Vincent township and to the north. Bolton (1957, p.42) notes that the Fossil Hill Dolomite thickens to the north, "an average thickness of 8 feet prevailing between Georgetown and Owen Sound, 12 to 16 feet in the Wiarton area, and 22 feet in the Hope Bay region."

St. Edmund Formation

At the type section three miles west of Cabot Head on the shore of the Georgian Bay, the St. Edmund Formation consists of 8 feet of thin-bedded, brown, fine grained to dense dolomite

that weathers white (Bolton 1957, p.39). Seven and one half feet of this formation are exposed at Dyer Bay. It is not present in Bolton's sections to the south. The formation thickens westward on Manitoulin Island. In the Niagara Escarpment sections it is only present to the north and west of Dyer Bay in Lindsay Township. This formation underlies the Fossil Hill Dolomite.

Wingfield Formation

The Wingfield Formation underlies the St. Edmund Formation in St. Edmund Township and farther to the south where the St. Edmund Dolomite pinches out, the Wingfield Formation underlies the Fossil Hill Dolomite and overlies the Dyer Bay Formation. The Wingfield Formation pinches out to the south in northern Keppel Township near Kemble. The Wingfield Formation is described in Bolton's Niagara Escarpment sections north and west of Kemble in Keppel Township.

Lithologically the Wingfield Formation consists of green to greenish grey shales and interbedded green to brown dense argillaceous dolomites (Bolton 1957, p.37). At Oxenden Falls in Keppel Township, Bolton's Section 140 describes 14 feet of Wingfield Dolomite. The formation thickens to 37 feet on Manitoulin Island (Bolton 1957, p.38).

Dyer Bay Formation

The Dyer Bay Formation extends from Manitoulin Island on to the Bruce Peninsula. It pinches out to the south just north of Owen Sound in Keppel and Sarawak Townships, but also occurs in northern Sydenham and St. Vincent Townships. It is underlain by Cabot Head Shales and overlain by the Fossil Hill Dolomite where the Wingfield Formation is absent. North of Kemble it is overlain by the Wingfield Formation.

The formation consists of a thin-bedded, brownish grey to blue-grey, finely crystalline dolomite with numerous green to grey shale partings (Bolton 1957, p.35). It thickens from 2 feet in St. Vincent Township to 15 to 20 feet at the type locality at Dyer Bay.

Cataract Group

As indicated on Table 1, Classification of the Stratigraphy of the Niagara Escarpment, at the type section at Niagara Falls, the Cataract Group consists, in descending order, of the Grimsby Formation, the Power Glen Formation and the Whirlpool Formation. The Power Glen Formation is replaced between Grimsby and Stoney Creek by the laterally equivalent Cabot Head Formation and underlying Manitoulin Formation. The Grimsby Formation is recognized as far north as Clappisons Corners beyond which it is replaced by the upper Cabot Head Formation.

Grimsby Formation

In the Niagara Escarpment type section at Niagara Falls, the Grimsby Formation consists of 50 feet of red and green mottled irregularly bedded sandstone with red shale interbeds, passing downward into red green-mottled shale with sandstone interbeds (Bolton 1964, p.67). Bolton (1957, p.19) recognizes the Grimsby as a distinct unit as far north as Clappisons Corners beyond which equivalent red beds are included in the Cabot Head Formation.

Power Glen Formation

In the Niagara Escarpment type section, the Power Glen Formation consists of 36 feet of dark grey to greenish grey shale with light grey to white calcareous sandstone interbeds (Bolton 1964, p.67). Bolton (1957) indicates that the Power Glen Formation has its northern limit between Grimsby and Stoney Creek where it is replaced by the Cabot Head and Manitoulin Formations.

Whirlpool Formation

In the Niagara Escarpment type section at Niagara Falls, the Whirlpool Formation consists of 18.5 feet of white to light grey massive crossbedded sandstone. The Whirlpool Sandstone is the lowermost formation of the Silurian from Niagara Falls to Duntroon along the Niagara Escarpment. It pinches out north of

Duntroon. The sandstone everywhere rests on the Upper Ordovician Queenston shales.

The Whirlpool Sandstone is an important building stone horizon which is quarried at Limehouse, Glen Williams and Inglewood.

Cabot Head Formation

At its type locality at Cabot Head in Lindsay Township on the Bruce Peninsula, the Cabot Head Formation consists of 74 feet of grey shale with interbeds of dolomitic limestone. Bolton (1957, p.17) states that the Cabot Head Formation is overlain successively from north to south by the Dyer Bay, Fossil Hill, Reynales or Grimsby Formations. It is underlain by the Manitoulin Dolomite. The Cabot Head Formation is recognized as far south as Stoney Creek.

Bolton (1957, p.17) states that "in almost every section between the type locality on the Bruce Peninsula and Hamilton, the Cabot Head strata include near the top a thin red facies of variable lithology and thickness, predominantly composed of red calcareous limestone, overlain by green shales of variable thickness. Neither unit is developed to such a degree, however, as to warrant formational rank. In the Stoney Creek-Hamilton region, red shales and sandstones are of sufficient importance to be assigned to the Upper Cataract Grimsby formation and

interpreted as a near-shore facies of the type Cabot Head. The Cabot Head formation in this area is thus restricted to the grey shales separating the Manitoulin and Grimsby formations. Still farther south and east the lithological unit known as the Cabot Head disappears entirely, its place being taken by part of the Power Glen Formation as well as the Grimsby. Furthermore, the Grimsby is overlain in the Niagara region by the Lower Clinton Thorold sandstone. As the latter is traced north it gradually grades into interbedded sandstone and shale (21). The green shales and underlying red arenaceous limestones in the Cabot Head sections north of Hamilton region, in the writer's opinion, are northern equivalents of the Thorold (?) and Grimsby. respectively, and will be so referred to in future discussions."

Manitoulin Formation

The Manitoulin Formation makes up part of the Niagara Escarpment from Stoney Creek north to Manitoulin Island. At Stoney Creek it consists of 4 feet of even-bedded, bluish grey to buff, crystalline dolomitic limestone (Bolton 1957, p.14). At Hamilton it thickens to 11 feet, and at Canning Falls to 26 feet. From this point the thickness is fairly constant. North of Stoney Creek the Manitoulin consists of thick to thin-bedded, grey, buff-weathering, dense to fine-grained argillaceous dolomitic limestone with grey shale partings and lenses of

white chert.

The Manitoulin Formation frequently forms a subsidiary scarp in the Niagara Escarpment section. Throughout the Niagara Escarpment from Stoney Creek to Duntroon, the Manitoulin Formation rests on the Whirlpool sandstone. North of Duntroon its lower contact is the Queenston Shale.

Queenston Formation

In the Niagara Escarpment type section at Niagara Falls, the lowermost unit is the upper part of the Queenston Shale of Ordovician age. The red Queenston Shale forms the base of the Niagara Escarpment from Niagara Falls to Kilgorie on the Pine River in Mulmur Township where the underlying Georgian Bay Formation becomes part of the escarpment due to uplift on the Algonquin arch in this area. From Kilgorie to the Beaver Valley the entire Queenston Formation makes up part of the Niagara Escarpment section and the base of the escarpment is in the Georgian Bay Formation. North and west of the Beaver Valley the Queenston Formation or part of it, again forms the basal unit of the Niagara Escarpment. North of Cape Dundas on the Bruce Peninsula, the Queenston Formation is below lake level except for a small stretch at Cabot Head.

The Queenston Formation consists of brick red, thin to medium-bedded shale, often with green mottling. Thin beds of

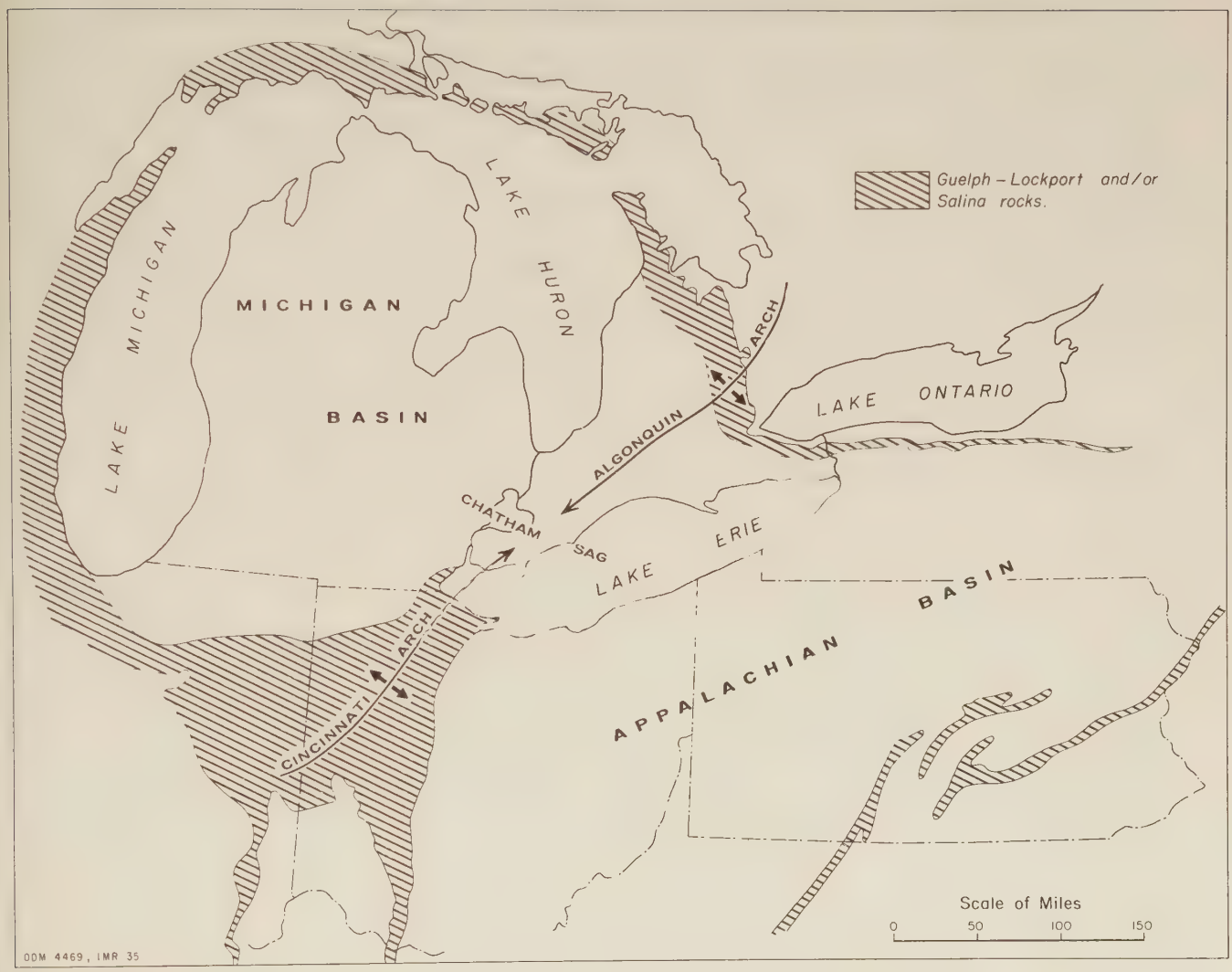

Figure 3 – Niagara Escarpment and major structural elements (from Vos 1969)

grey-green and reddish argillaceous limestone occur in most sections. The Queenston Shale breaks down readily into a red clay soil which is a conspicuous feature along the base of the Niagara Escarpment at Aldershot, Georgetown, Terra Cotta, Cheltenham, Inglewood and other places. The Queenston Formation thins from about 800 feet at Queenston to about 200 feet at Cabot Head.

Georgian Bay Formation

The Georgian Bay (Meaford-Dundas) Formation forms part of the Niagara Escarpment from Kilgorie on the Pine River in Mulmur Township northward to Heathcote near the mouth of the Beaver Valley. Although usually only the upper part of the Georgian Bay Formation is included in the Escarpment, at The Caves in Collingwood Township the entire Georgian Bay Formation makes up the lower 400 feet of the Niagara Escarpment. Here the base of the Escarpment corresponds with the Lake Algonquin shorecliff a mile west of Mair Mills. The Escarpment at The Caves has a height of over 800 feet.

The Georgian Bay Formation consists of an upper member 30 to 50 feet thick of grey limestone with shaly partings, and a lower member composed of blue or grey shale with thin interbeds of sandstone, limestone and dolomite (Liberty 1969, p.75-76).

Regional Description

A cuesta is a gently sloping structural plain terminated up dip by an escarpment. The gently dipping Guelph and Lockport-Amabel Dolomites form a cuesta dipping away from the face of the Niagara Escarpment to the south and west. The elevations of the cuesta surface at the edge of the Niagara Escarpment rise from 550 feet a.s.l. at Queenston, to 700 feet a.s.l. at Dundas, 900 feet a.s.l. at Mount Nemo, 1450 feet a.s.l. at Credit Forks, 1600 feet a.s.l. near Honeywood and to 1700 a.s.l. near Glen Huron in Nottawasaga Township. This is on the axis of the Algonquin arch and from The Caves where the cuesta has an elevation of 1675 feet a.s.l. the elevations begin to fall again to the northwest. The elevations of the cuesta surface at the edge of the Niagara Escarpment fall to the northwest of Collingwood, being 1475 feet a.s.l. at Duncan, 1375 feet a.s.l. at Kimberley, 1250 feet a.s.l. at Bayview, 800 feet a.s.l. at Owen Sound, 950 feet a.s.l. at Skinner Bluff, 825 feet a.s.l. at Hope Bay, 700 feet a.s.l. at Cape Chin, and 650 feet a.s.l. at Driftwood Cove.

The Niagara Escarpment section in the Niagara Gorge has already been described. At Queenston Quarries the top of the Escarpment has an elevation of about 550 feet a.s.l., with the base at about 375 feet a.s.l. From Queenston to Hamilton the base of the Escarpment is maintained at about 375 feet a.s.l. At Queenston Quarries the edge of the Escarpment is Lockport

Photo 7. The Niagara Escarpment section exposed in the Niagara Gorge is an unmantled rock scarp as shown in this photo looking north towards the Whirlpool on the Niagara River at Niagara Falls. A complete section from the Lockport Dolomite to the Queenston Shale is exposed. Photo courtesy of the Ontario Department of Tourism and Information.

Dolomite. A narrow shelf occurs on top of the Irondequoit Limestone and the Irondequoit and Reynales Formations form a minor subsidiary scarp in this region. The Escarpment base is at the top of the Queenston Shale.

From St. Davids to The Whirlpool, the Niagara Escarpment is breached by the St. Davids buried gorge, a pre-Wisconsinan river valley. It is probable that the St. Davids buried gorge does not cut down through all the Niagara Escarpment formations, but may bottom in formations of the Cataract Group. For this reason Queenston Quarries and the reservoir are located on what may be termed the Queenston attached outlier.

Between St. Davids and Thorold the Lockport Dolomite forms the caprock of the Niagara Escarpment, with an elevation at Walker Brothers Quarries of about 575 feet a.s.l. The base of the escarpment formations is the top of the Queenston Shale at an elevation of about 375 feet a.s.l. About a mile northeast of Walker Brothers Quarries, there is a subsidiary scarp of Irondequoit and Reynales Limestones. The distance from the Lockport brow of the Escarpment to the base at the top of the Queenston Shale in some places exceeds 9000 feet. In this area the top of the Queenston Shale frequently coincides with the Lake Iroquois shorecliff close to No. 8 highway.

Just north of Thorold in Merritton close to the tracks of the former Niagara Central Railway, quarries were operated in the

Whirlpool Sandstone which formed a cliff about 20 feet high in this part of the Escarpment (Parks 1912, p.140). In this area the Niagara Escarpment may form three multiple scarps, Lockport, Irondequoit-Reynales and Whirlpool. The dominant scarp is the Lockport Dolomite.

At Sanatorium Hill in St. Catharines, the quarry of St. Catharines Crushed Stone which quarries Lockport Dolomite is located on the brow of the Escarpment. The elevation of the top of the Niagara Escarpment at this locality is about 550 feet a.s.l. and the base is at approximately 375 feet a.s.l.

Farther west one of the best complete Niagara Escarpment sections has been described by Bolton (1957, p.83) at DeCew Falls where all the formations from the Lockport Dolomite brow to the Queenston Shale base are exposed.

West of DeCew Falls, Twelve Mile Creek forms a reentrant valley cutting back about two and a half miles south into the face of the Niagara Escarpment. The brow of the Escarpment is cut back to Effingham where both Lockport and Clinton rocks are exposed marking the position of the Escarpment brow. The position of the Escarpment base has not yet been determined due to the infilling of the reentrant valley by glaciofluvial deposits of considerable thickness.

At Rockway Falls on Fifteen Mile Creek a section from Lockport Dolomite to Grimsby Sandstone (Bolton 1957, p.84-85),

is exposed. Queenston Shale is exposed in Fifteen Mile Creek a half mile northeast of Rockway Falls. The elevation of the top of the Escarpment at this locality is about 550 feet a.s.l. with the base at approximately 350 feet a.s.l.

From Rockway Falls to a mile west of Vineland the Niagara Escarpment is usually composed of two scarps, the Lockport and the Irondequoit-Reynales. In places as at Vineland Quarries the latter is dominant. At Vineland Quarries the elevation of the top of the Escarpment is about 575 feet a.s.l. with the base being at about 375 feet a.s.l.

At Beamsville the elevation of the top of the Niagara Escarpment is about 600 feet a.s.l. The position of the base is not well defined but there is a break in gradient at about 375 feet a.s.l. which corresponds to the Lake Iroquois shore cliff which is cut in Queenston Shale.

From Grimsby to Hamilton the Niagara Escarpment generally forms a single narrow scarp with a relief of 225 to 275 feet. At Grimsby the elevation of the top of the Escarpment is about 600 feet a.s.l. and the base is at approximately 350 feet a.s.l. In Grimsby Gorge the Irondequoit-Reynales ledge supports a subsidiary falls well downstream from the Lockport falls. At Vinemount the top of the Escarpment is at about 625 feet a.s.l. and the base is at about 350 feet a.s.l. The width of the face does not exceed 1000 feet at this locality and the gradient is very steep.

A reentrant valley has been cut back for over a mile and a half at Mount Albion by Redhill Creek. The top of the Escarpment at Mount Albion has an elevation of about 600 feet a.s.l. and the base is at about 375 feet a.s.l.

Through Hamilton the Niagara Escarpment forms a steep simple scarp face known locally as the Mountain. The elevation of the top of the Escarpment is between 600 and 625 feet a.s.l. and the base is at about 375 feet a.s.l.

From Queenston to Ancaster the Niagara Escarpment runs westerly. At Ancaster the Escarpment swings northeast and then trends northward through Orangeville.

Between Ancaster and Dundas, the Dundas valley forms a broad reentrant which extends west at least as far as Mineral Springs where outcrops of Lockport Dolomite are found. The Dundas valley has been regarded by Karrow (1963), Chapman and Putnam (1966) and others as a preglacial valley. The latest description is that of Straw (1968, p.903), who shows the Dundas valley as terminating west of Copetown.

At the Dundas quarry of Canada Crushed Stone, the top of the Niagara Escarpment has an elevation of about 700 feet a.s.l. and the base of the Escarpment is about 500 feet a.s.l. at Dundas. The face of the Niagara Escarpment from Dundas north to Mount Nemo and Cedar Springs is a well defined simple Amabel-dominant scarp with the lower flanks largely mantled by glacial drift.

East of Waterdown the top of the Escarpment has risen to 825 feet a.s.l. due to the southwesterly dip. The base is not well marked as the foreslope is largely in dissected Queenston Shale between Waterdown and Ancaster. The base may be tentatively placed at about 500 feet a.s.l. in this area but the base is not well characterized by any marked change in gradient.

The Niagara Escarpment forms a prominent cliff of Amabel Dolomite at Mount Nemo where the top of the escarpment is at about 900 feet a.s.l. and the base at about 600 feet a.s.l. in Queenston Shale. A buried valley extends south-southeast from Cedar Springs to Lake Medad. The reentrant valley of Bronte Creek extends southwest of Cedar Springs to the vicinity of Progreston.

From Kilbride the Niagara Escarpment extends north to Campbellville which is at the head of the reentrant valley which is traversed by Highway 401. Southwest of Milton lies the large Milton outlier of Niagara Escarpment rocks. This outlier is 2½ miles long in a north-south direction and 2 miles wide. It terminates at the south in the cliff promontory of Rattlesnake Point. The Milton outlier is separated from the main Escarpment area by a narrow and deep valley which cuts down into the Queenston Shale on the southwest side of the outlier. This valley formed a glacial meltwater channel and a kame gravel terrace was formed southwest of Rattlesnake Point. The edges

of the Milton outlier form a steep Amabel-dominant scarp whose lower slopes are generally mantled by glacial drift. The quarries of Milton Brick Company are in Queenston Shale in the lower part of the Escarpment. Whirlpool Sandstone was also formerly quarried on the north face of this outlier.

At Rattlesnake Point the top of the Escarpment has an elevation of about 1000 feet a.s.l. and the base is placed at about 750 feet a.s.l. in Queenston Shale. At Milton Heights on the north side of the Milton outlier, the Niagara Escarpment has an elevation of about 1000 feet a.s.l. and the base is again at 750 feet a.s.l. in Queenston Shale.

A well marked narrow Amabel-dominant mantled scarp extends north from Campbellville to Scotch Block. At Dufferin Quarry the elevation of the top of the Escarpment is about 1075 feet a.s.l. and the base is at approximately 800 feet a.s.l.

From Scotch Block to Limehouse the Niagara Escarpment is largely mantled or buried, but there are numerous small quarries in Whirlpool Sandstone in Esquesing Township. A small outlier of Amabel Dolomite lies just southeast of Limehouse and the Escarpment edge of Amabel Dolomite outcrops at Limehouse. The edge of the Escarpment is also exposed south of Acton in the vicinity of the Acton quarry of Indusmin Limited.

From Limehouse, the Niagara Escarpment can be traced north to Caledon Mountain west of Cheltenham and Inglewood. The

abandoned Georgetown quarry of Armstrong Brothers Company south of Silver Creek, lies on the edge of the Escarpment. Here the top of the Escarpment has an elevation of about 1050 feet a.s.l. and the base of the Escarpment is placed at about 950 feet a.s.l. in Queenston Shale.

Two miles northwest of Glen Williams, there is a small outlier capped by Amabel Dolomite. This Glen Williams outlier has a north-south length of a mile and a half and a width of one half mile. Several small Whirpool Sandstone quarries operate in this outlier which is separated from the main section of the Escarpment by a deep narrow valley.

West of Inglewood the Niagara Escarpment is represented by Caledon Mountain. At this locality the top of the Escarpment rises from 1325 feet a.s.l. near Inglewood to about 1450 feet a.s.l. at Devils Pulpit east of Credit Forks. The base of the Escarpment in this area is about 1000 feet a.s.l. West of Inglewood the Whirlpool Sandstone forms a shelf on the face of the Escarpment.

From Credit Forks and Cataract a partly buried valley through the Amabel Dolomite extends northerly through Alton and Melville to Orangeville and the head of the Hockley Valley. The whole of the Escarpment area east of this valley might be regarded as an attached outlier to which the name Caledon outlier may be applied.

The Amabel cliff on the west side of this Caledon outlier is exposed a mile east of Alton. From this point the Escarpment extends in an arc to the eastward passing south of Caledon to outcrop again at Star in concession III E of Caledon Township. From east of Alton to Star the Niagara Escarpment is buried by the Paris Moraine and the Caledon meltwater channel (see page 11). As was pointed out the Caledon Hills form a consequent moraine slope covering the face of the Niagara Escarpment across Caledon Township. At Star the elevation of the top of the Escarpment is about 1425 feet a.s.l. The base has not been determined, but stratigraphically it should be about 1000 feet a.s.l. in bedrock. A small Amabel outlier occurs at Star.

From Star to Sleswick the Escarpment is again buried, but then outcrops at Sleswick and The Dingle. At The Dingle the Escarpment has an elevation of about 1475 feet a.s.l. The base of the Escarpment in Queenston Shale is buried.

At Mono Mills a tributary of the Humber River forms a reentrant in the Escarpment and is cut into Queenston Shale. As previously described, the edge of the Niagara Escarpment forms a hill west of the Airport Road in Mono Township at an elevation of about 1475 feet a.s.l. A gravel terrace with an elevation of almost 1425 feet a.s.l. extends eastward for over a mile and completely buries the rest of the face of the Niagara Escarpment in this area. As pointed out the consequent slope in this area

which represents the topographic expression of the buried Niagara Escarpment is the eastern edge of the gravel terrace in concessions VII and VIII of Mono Township.

The Niagara Escarpment again outcrops in lot 7, concessions VI and VII, Mono Township on the Airport Road where outcrops of Amabel Dolomite and Whirlpool Sandstone are exposed. From this point the face of the Niagara Escarpment is largely buried along the south side of the Hockley Valley to Orangeville.

At the head of the Hockley Valley in the old Nicholson quarry, (lot 6, concession I E, Mono Township), the Queenston Shale, Whirlpool Sandstone and Manitoulin Limestone which form the lower part of the Niagara Escarpment are exposed. In lots 6 and 7, concession I W, Mono Township, a similar section of Niagara Escarpment rocks is exposed in the old Owen Sound quarries. At the Nicholson quarry the top of the Queenston Shale has an elevation of 1264 feet a.s.l.

From this locality on the Hockley Valley Road the Niagara Escarpment is largely buried for two miles to Cannings Falls, where a complete section of 157 feet of Niagara Escarpment rocks have been measured by Bolton (1957, p.97) from the top of the Queenston Shale. This includes 49 feet of Colpoy Bay (Amabel) Dolomite which is the dominant scarp former at the top of the section. The elevation of the top of the Escarpment at Canning Falls is 1465 feet a.s.l.

North of Canning Falls the Niagara Escarpment is well defined in lot 15, concessions III and IV E, Mono Township, and forms a series of east-facing bluffs in concession III E to lot 28. At Mono Centre there is a small outlier of Amabel Dolomite in front of the main face of the Escarpment. The lower portion of the face of the Escarpment in this area is mantled by gravel terraces of the Violet Hill meltwater channel extending south to Orangeville along the Escarpment face.

The face of the Niagara Escarpment is buried along No. 89 Highway west of Violet Hill, but outcrops are again found in the Boyne River reentrant north of Primrose. The Amabel Dolomite forms a prominent bluff north and east of Whitfield in Mulmur Township. At this locality the elevation of the top of the Escarpment is about 1575 feet a.s.l. The assumed base is in Queenston Shale at an undetermined elevation.

A deep reentrant valley of the Pine River cuts westward into the Escarpment from Kilgorie to Hornings Mills, where a complete section of Niagara Escarpment rocks from the Amabel Dolomite to the Manitoulin Formation is described by Bolton (1957, p.98). From Hornings Mills the Niagara Escarpment forms a bluff with sparse outcrop extending north through Mulmur Township east of Honeywood to Lavender. To the east of this bluff lies the large Ruskview outlier which is five miles long in a north-south direction, and two miles wide. The valley separating the

Ruskview outlier from the main Escarpment runs through Lavender to Black Bank, and is quite narrow. As previously described the northern 3 miles of the Ruskview outlier is stripped of Amabel Dolomite and the actual brow of the Escarpment is Manitoulin Formation.

East of Honeywood the elevation of the top of the Escarpment is about 1600 feet a.s.l. and the base is in Georgian Bay Shale at about 1000 feet a.s.l. At Ruskview the elevation of the top of the Escarpment is about 1600 feet a.s.l. and the base is in Georgian Bay Shale at about 1000 feet a.s.l. At this locality the Niagara Escarpment is largely buried with only scattered outcrops.

South of Creemore the crest of the Escarpment atop the Manitoulin Formation has an elevation of about 1550 feet a.s.l. The base of the Escarpment is at about 900 feet a.s.l. in Georgian Bay Formation.

At the Creemore stripped incised outlier, the elevation of the presently exposed top of the Escarpment is at about 1350 feet a.s.l. in Queenston Shale. The base is at about 900 feet a.s.l. in Georgian Bay Shale.

The Noisy River flowing northeast through Dunedin has cut a prominent reentrant valley in the Niagara Escarpment face. South of Dunedin a prominent rocky bluff of Amabel Dolomite extends two miles to the southwest. Here the elevation of the top of the Escarpment is about 1600 feet a.s.l. and the base

is at about 1125 feet a.s.l. in Georgian Bay Shale.

From the Noisy River reentrant north to the Mad River reentrant which extends west from Glen Huron to Singhampton, there is an Amabel-dominant scarp of considerable relief. Southwest of Glen Huron the top of the Amabel bluff which caps the Escarpment has an elevation of about 1700 a.s.l., with the base at about 1100 feet a.s.l. in the Georgian Bay Formation. From here north to The Caves the top of the Escarpment attains its maximum elevation of 1675 to 1700 feet a.s.l.

West of Duntroon a marked bluff of Amabel Dolomite stands at 1650 to 1700 feet a.s.l. A secondary scarp in Whirlpool Sandstone is at about 1550 feet a.s.l. and the base of the escarpment is at about 1100 feet a.s.l. in the Georgian Bay Formation.

Northwest of Duntroon there is a large reentrant formed by the Pretty River. A moraine lies across this valley. Immediately to the north is Osler Bluff, a prominent Amabel-dominant scarp standing at about 1650 feet a.s.l. The base of the Escarpment, is at about 900 feet a.s.l. in the Georgian Bay Formation.

Another prominent cliff face occurs about 3 miles to the north at The Caves. Here the top of the Amabel Dolomite cliff is at about 1675 feet a.s.l. and the base is at the base of the Lake Algonquin shorecliff, which forms part of the Escarpment at

this point, with an elevation of about 800 feet a.s.l. near the base of the Georgian Bay Formation.

At the north end of the Blue Mountain between Craigleith and Camperdown the Amabel Dolomite caprock has been stripped back about two miles and there is an outlier of Manitoulin Dolomite standing at elevation 1425 feet a.s.l. The base of the Escarpment just south of Highway 26 lies at about 700 feet a.s.l. at the base of the Georgian Bay Formation and here the Escarpment base corresponds with combined Lake Algonquin and Lake Nipissing shorecliffs.

From the Blue Mountain promontory, the Niagara Escarpment trends southwest into the major reentrant of the Beaver Valley which extends south for about 20 miles from Georgian Bay. The origin and form of the preglacial valley which has been U-shaped by glacial action is well described by Chapman and Putnam (1966, p.188 - 194). Prominent bluffs of Amabel Dolomite occur between Camperdown and Duncan in many places. At Duncan the Amabel bluff has an elevation of about 1500 feet a.s.l. The Escarpment slopes steeply to about 1100 feet in Queenston Shale and the base of the Escarpment is not well defined in this area. The Beaver River valley is only 4 miles wide between Duncan Lake and Epping. At Duncan Lake the Escarpment descends from 1400 feet a.s.l. on the Amabel Dolomite crest to 775 feet a.s.l. on the valley floor seven-eighths of a mile away.

Photo 8. The Beaver Valley forms a deep reentrant in the Niagara Escarpment. This view, near Kimberley, shows the Escarpment is buried or mantled in this area with scattered outcrops of the Amabel rimrock. Photo courtesy of the Niagara Escarpment Study Group.

At Epping the Amabel Dolomite crest has an elevation of about 1375 feet a.s.l. with the base of the Escarpment at valley floor level of 775 feet a.s.l. a mile and a quarter to the east.

From the Beaver Valley to Tobermory at the tip of the Bruce Peninsula, a series of excellent mile to the inch geological and topographical maps are available in B.A. Liberty's G.S.C. Paper 65-41: Geology of the Bruce Peninsula, Ontario (Liberty 1966). The reader is referred to these maps for the following descriptions of the Niagara Escarpment on the Markdale (map 23-1965), Owen Sound (map 21-1965), Cape Croker (map 19-1965) and Tobermory (map 18-1965) sheets.

Also of value in following the general description of the Niagara Escarpment north of Griersville, is Geological Survey of Canada map 1194A (Liberty 1969), on the scale of 4 miles to the inch.

The bedrock floor of the Beaver Valley to within a mile of Eugenia is in the Georgian Bay Formation, and the Niagara Escarpment forming the valley sides is composed of a complete section from Amabel Dolomite into Georgian Bay Formation. However good exposures are scarce as the Escarpment face is extensively mantled by glacial drift.

At Kimberley where the Beaver Valley is a mile and three-quarters wide, the east face of the Escarpment is capped by a bluff of Amabel Dolomite at an elevation of about 1400 feet a.s.l.

The valley floor at the base of the Escarpment has an elevation of 800 feet a.s.l. and the bedrock is Georgian Bay Formation.

The Amabel promontory on the west side of the Beaver Valley is Griersville Rock standing at an elevation of about 1350 feet a.s.l. The secondary Manitoulin scarp lies about one half mile north of the Amabel scarp at about 1225 feet a.s.l. From Griersville Rock, the Niagara Escarpment cuts back southwest in a broad reentrant some 8½ miles wide, the Bighead Valley. The west side of the Bighead reentrant is marked by a usually well-defined Amabel Dolomite bluff extending northeasterly through Woodford for a distance of about 8 miles.

From Griersville Rock to Walters Falls the Niagara Escarpment crest is marked by scattered outcrops of Amabel Dolomite and the escarpment falls off to the base of the Manitoulin Dolomite. Below this point the valley basin is one big drumlin field and no further topographic expression of the Escarpment is seen. This drumlin field also occupies the valley area south and east of Woodford southeast of the Amabel bluff. Within the Bighead Valley the Niagara Escarpment is largely a buried scarp or an Amabel-dominant mantled scarp. The prominent topographic scarp running along south of No. 26 highway for 5 miles east of Meaford is a Lake Algonquin shorecliff or scarp cut in the Georgian Bay Formation and it is probable that this should be considered as part of the Niagara Escarpment.

Photo 9. This photo shows the mantled and partly drowned Niagara Escarpment at Hope Bay on the Bruce Peninsula. Photo courtesy of the Ontario Department of Tourism and Information.

The Amabel Dolomite cuesta extends from Hoath Head in Sydenham Township ten miles to the northeast past Woodford into St. Vincent Township. The Niagara Escarpment falls off both on the southeast and northwest sides of the Amabel cuesta. North of Bayview the east-facing Amabel bluff has an elevation at its top of about 1275 feet a.s.l. The Manitoulin scarp is one-half mile east with an elevation on top of about 1075 feet a.s.l. The St. Vincent, Silcote and Coffin Hill attached outliers of Manitoulin Dolomite lie in an east-west line to the north and form part of the Niagara Escarpment.

Owen Sound and the Sydenham valley form a large reentrant valley into the Niagara Escarpment at Owen Sound. Prominent bluffs of Amabel Dolomite and secondary scarps of Manitoulin Dolomite form the Niagara Escarpment at Owen Sound city north of Inglis Falls. The Amabel cuesta east of the Sydenham River at Owen Sound has an elevation of about 875 feet a.s.l., while the Amabel cuesta to the west has an elevation of about 825 feet a.s.l. North of No. 6 highway, west of Owen Sound the top of the Amabel bluff has an elevation of about 800 feet a.s.l.

Between Owen Sound and Wiarton in Sarawak and Keppel Townships, the Amabel scarp is dominant. There is usually a subsidiary scarp in Manitoulin Dolomite, and the Niagara Escarpment face passes below the surface of the Georgian Bay in these townships. Prominent features of the Escarpment in Keppel Township include Dodds

Photo 10. The Niagara Escarpment at Lions Head on the Bruce Peninsula consists of a steep rock face of Amabel Dolomite with the lower flanks mantled by drift and drowned by the waters of the Georgian Bay. Photo courtesy of the Ontario Department of Tourism and Information.

Hill, Halliday Hill, Esther Cliff and Skinner Bluff. At Skinner Bluff the Amabel Dolomite cuesta has an elevation of 950 feet a.s.l. The level of Georgian Bay is approximately 580 feet a.s.l.

North of Wiarton the Amabel Dolomite bluffs are dominant all along the east shore of the Bruce Peninsula, and form a series of headlands. The lower part of the face of the Niagara Escarpment is drowned. Cape Croker forms an attached outlier of the Escarpment. At Malcolm Bluff the Amabel cuesta has an elevation of about 925 feet a.s.l., while at Cape Dundas the elevation of the top of the Amabel Dolomite is about 875 feet a.s.l.

North of Lions Head between White Bluff and Smoky Head the Guelph Dolomite caps the Niagara Escarpment along the Georgian Bay shorecliff at an elevation of about 725 feet a.s.l. As mentioned previously the Guelph Dolomite also caps the shorebluff nearly continuously from west of Cabot Head to Tobermory. At Driftwood Cove the cuesta has an elevation of about 650 feet a.s.l.

Photo 11. A view of Middle Bluff from across Wingfield Basin. Photo courtesy of the Niagara Escarpment Study Group.

Photo 12. Flowerpot Island is an outlier of the Niagara Escarpment lying offshore in the Georgian Bay near Tobermory. The steep rock face of the Escarpment outlier is seen in this photo. The "flowerpots" are erosional stacks of dolomite. Photo courtesy of the Ontario Department of Tourism and Information.

Summary

1. The Niagara Escarpment is defined as a steep rock face cut in a rock section which extends stratigraphically at the type section at Niagara Falls, from the Lockport Dolomite to the upper part of the Queenston Shale. In other localities the Niagara Escarpment extends as high stratigraphically as the lower part of the Guelph Dolomite, and as low stratigraphically as the base of the Georgian Bay Formation.

2. Various types of scarps are recognized such as the rock scarp, the mantled scarp, the buried scarp, multiple scarps, incised scarps and outliers.

3. The Niagara Escarpment is primarily defined on a geological and geomorphological basis. Change in gradient is an important factor in picking the brow and the base of the escarpment. Topographical evidence of a scarp must be correlated with the geology to ensure that the scarp feature being defined is actually related to the Niagara Escarpment, a bedrock feature.

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